

AASHTOWare Bridge Rating Training

DF3 – Distribution Factor Analysis (LRFR)

Topics Covered

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- Non-standard gage vehicle description
- Vehicle paths

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Part 1: Review Distribution Factor Analysis

This example describes the distribution factor analysis feature in BrR to determine the adequacy of a superstructure for a standard gage or non-standard gage vehicle.

Distribution Factor Analysis Method of Solution

The Distribution Factor Analysis feature computes live load distribution factors for a vehicle traveling in a specified path along the length of the superstructure. This feature allows you to analyze a bridge for standard gage or non-standard gage vehicles.

A 3D and a 2D finite element analysis of the superstructure is performed and moment and shear live load distribution factors are computed for a vehicle traveling along user-specified paths along the length of the superstructure. The computed distribution factors are then used to perform a rating analysis using traditional line girder analysis techniques.

In the 3D finite element model, the deck is modeled as shell elements and the girders are modeled as beam elements. The deck is always included in the model regardless of whether the girders are composite with deck. Diaphragms are not included in the 3D finite element model.

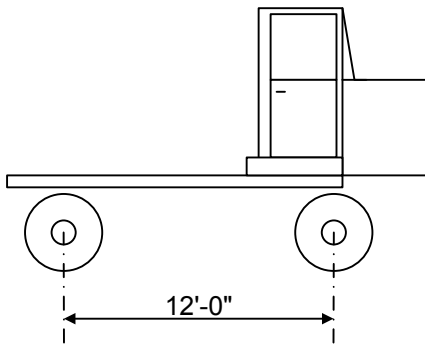
BrR determines which nodes in the 3D FE model should be loaded with the vehicle by using the vehicle path location and vehicle wheel description entered by the user. Unit loads are placed at each of these nodes in the 3D FE model and the resulting moment and shear element forces in the beam elements are stored. Moment and shear influence surfaces are generated from these element forces. The influence surfaces are then loaded with the vehicle traveling along the user-defined vehicle path. The moments and shears in the girders due to the actual distribution of the vehicle through the deck are then computed.

A 2D finite element analysis is then performed for each girder. The 2D FE model consists of the girder modeled as beam elements. The nodes in the 2D FE model are at the same locations as the nodes in the 3D FE model.

Unit loads are placed at each node along the girder in the 2D FE model and the moment and shear influence lines are generated for the girder. These influence lines are then loaded with the axle weights of the vehicle traveling along the superstructure and the resulting moments and shears in the girder are then computed.

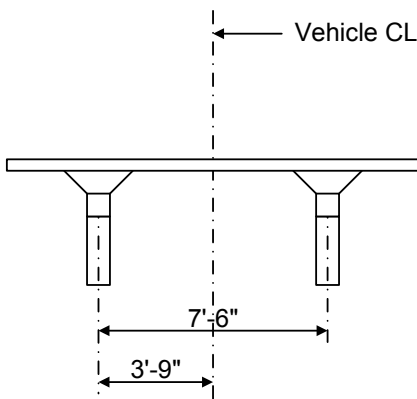
Moment and shear distribution factors are computed by dividing the 3D model moments and shears by the 2D model moments and shears. These distribution factors are the ratio of the 3D actions to the 2D actions. The critical moment distribution factor is chosen for each vehicle path by first finding the moment distribution factors that correspond to the maximum 2D moment and the minimum 2D moment. The critical moment distribution factor is the maximum of these 2 moment distribution factors. The critical shear distribution factor is determined in the same manner. A traditional line girder analysis of the girder is then performed using these critical distribution factors.

Non-standard gage vehicle description

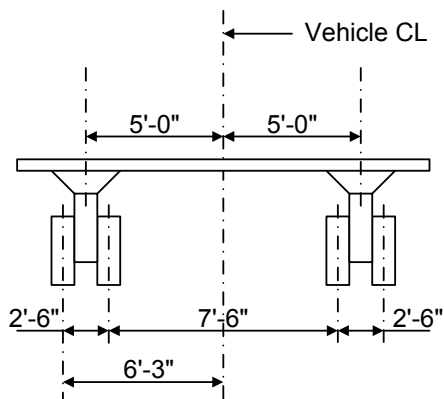


Elevation View

NSG Truck Load Data		
Front Axle	Load/Axle Line	40 kips
	Load/Tire	20 kips
Rear Axle	Load/Axle Line	48 kips
	Load/Tire	12 kips
Total Vehicle Weight		88 kips

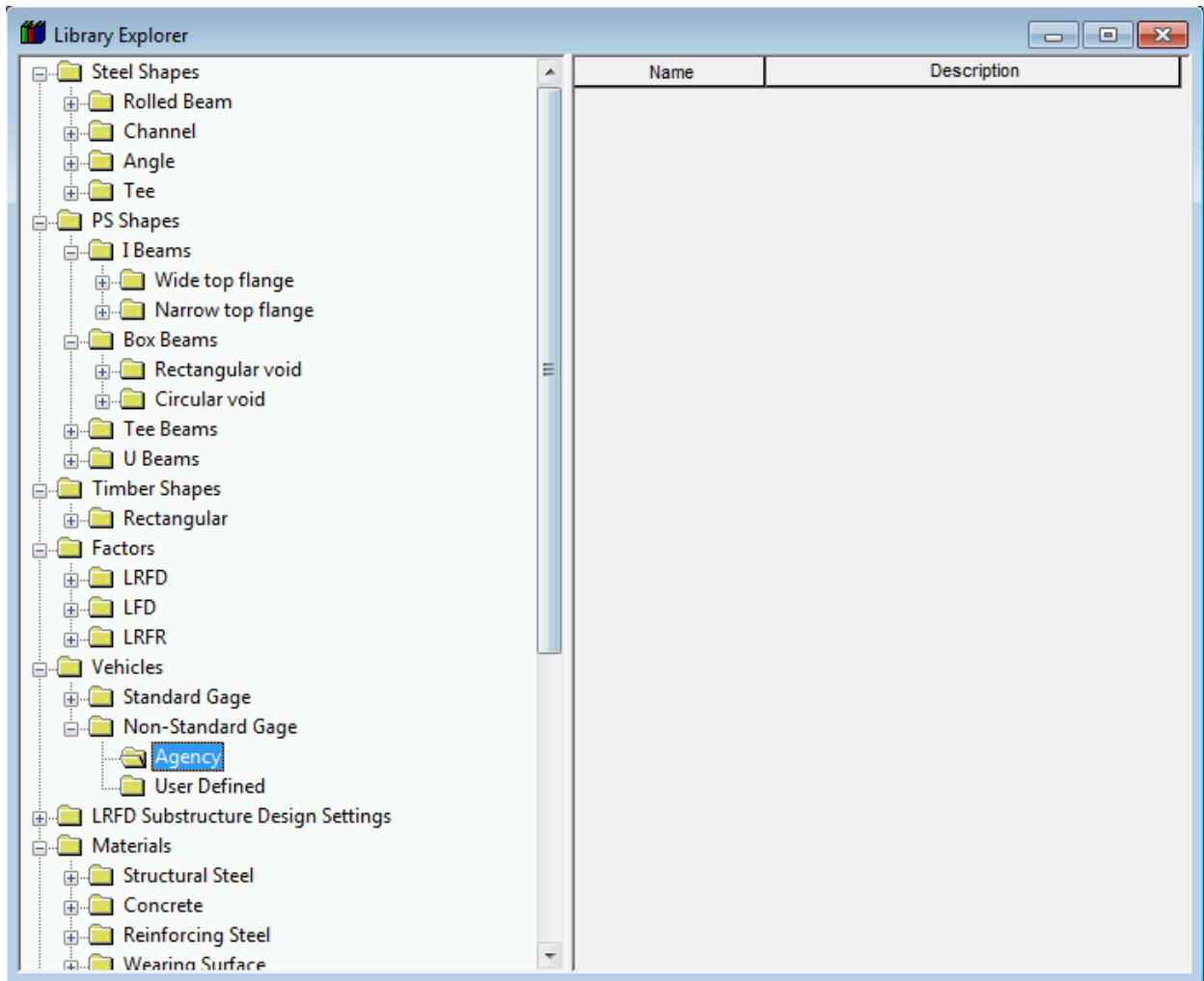


End View of Front Axle



End View of Rear Axle

The preceding non-standard gage vehicle can be entered in the BrDR vehicle library as follows. Open the Library Explorer and select Agency under Non-Standard Gage/Vehicles in the Library tree. Select File/New from the menu to open the Non-Standard Gage Vehicle window.



The description for the first axle of the vehicle is shown below.

Library - Non-Standard Gage Vehicle

Name: NSG Truck

Description:

Store units as: US SI

Library: Standard Agency Defined User Defined

Description

Axes

Axle	Distance to First Wheel (ft)	Axle Spacing (ft)	Total Axle Load (kip)
1	-3.750		40.00
2	-6.250	12.00	

Totals: 12.00 40.00

New Duplicate Delete

Wheels

Axle: 1


Wheel	Wheel Spacing (ft)	Wheel Contact Width (in)	Wheel Load (kip)
1		16.0000	20.000
2	7.500	16.0000	20.000

Total (for axle): 40.00

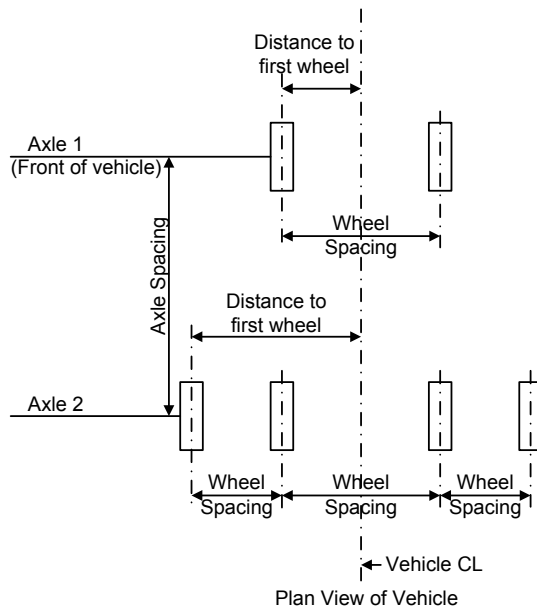
New Duplicate Delete

Rating: ASD/LFD LRF

Save Close

 Be sure to check the rating boxes so that you will be able to select this vehicle in the Analysis Settings window when doing the rating.

When describing the axles, the Distance to First Wheel is the distance from the centerline of the vehicle to the first wheel in the axle. This value is a negative value to signify the first wheel is to the left of the vehicle centerline. The following sketch illustrates the terminology used in this window.



The description of the wheels in the second axle of the vehicle is shown below.

Library - Non-Standard Gage Vehicle

Name:

Description:

Store units as: US SI

Library: Standard Agency Defined User Defined

Rating: ASD/LFD LRFr

Description

Axes

Axle	Distance to First Wheel (ft)	Axle Spacing (ft)	Total Axle Load (kip)
1	-3.750		40.00
2	-6.250	12.00	36.00

Totals:

Wheels

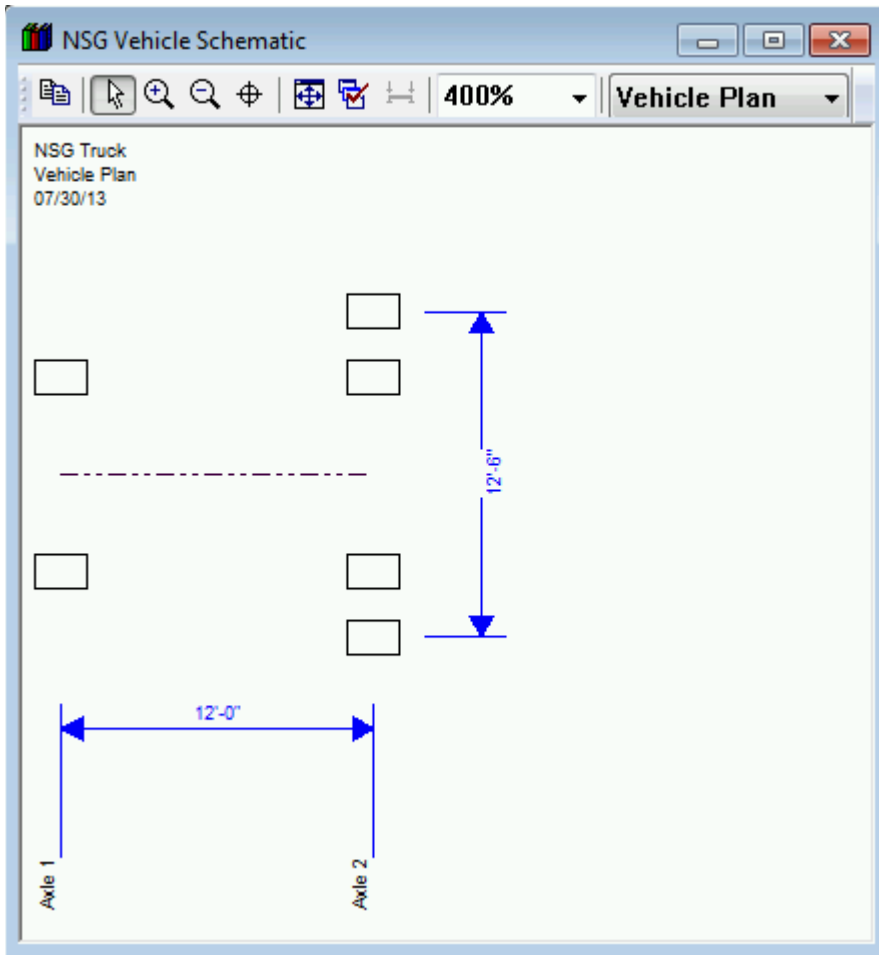
Axle:

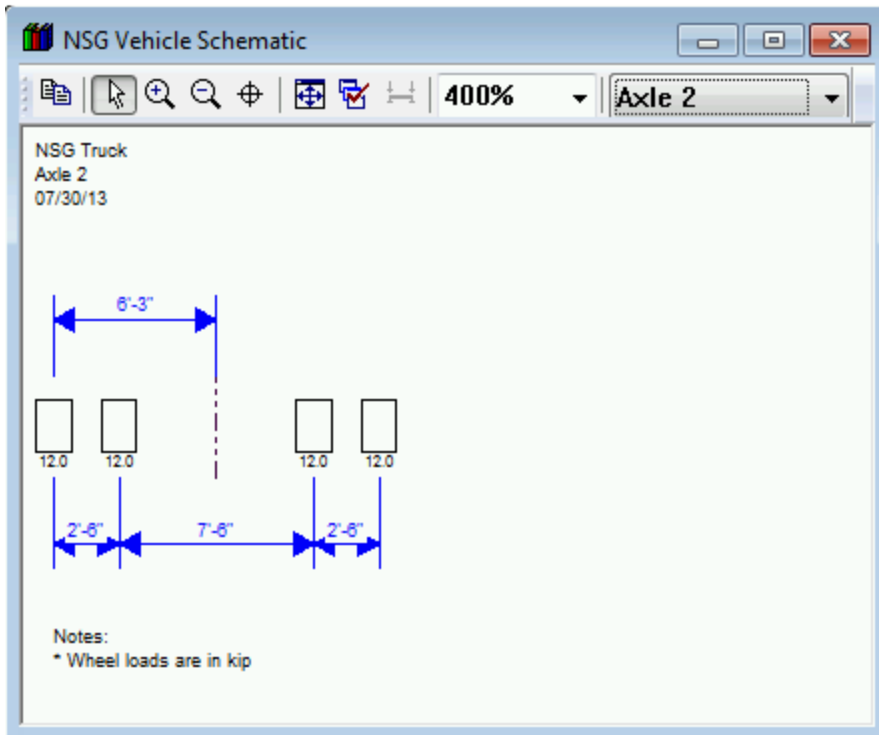
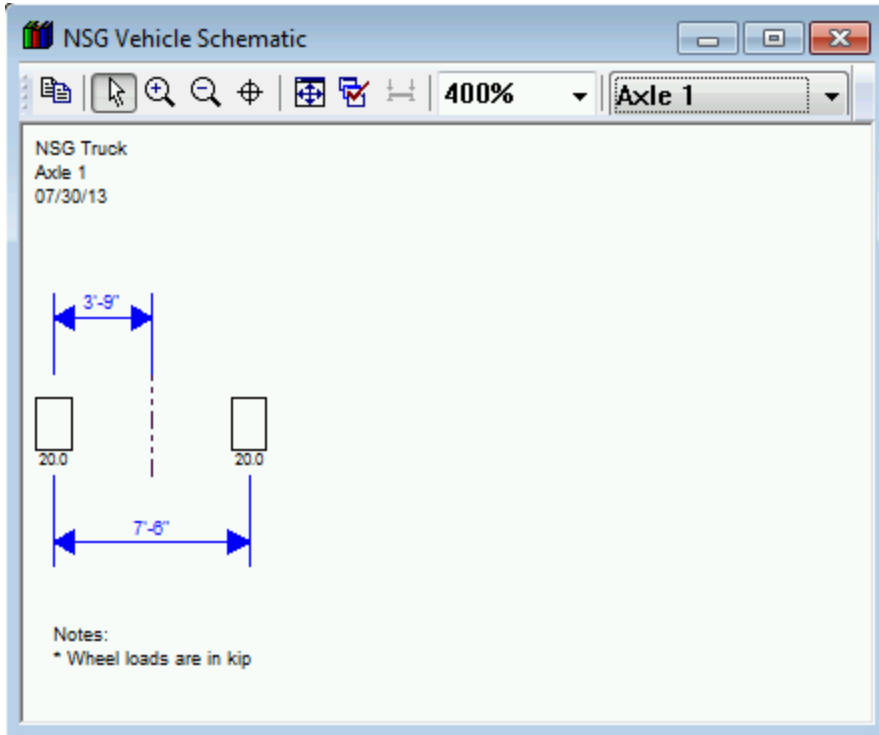
Wheel	Wheel Spacing (ft)	Wheel Contact Width (in)	Wheel Load (kip)
1		16.0000	12.000
2	2.500	16.0000	12.000
3	7.500	16.0000	12.000
4	2.500	16.0000	12.000

Total (for axle):

Click Save to save this vehicle to the library.

A schematic view of the vehicle and each axle is available to verify your data entry.

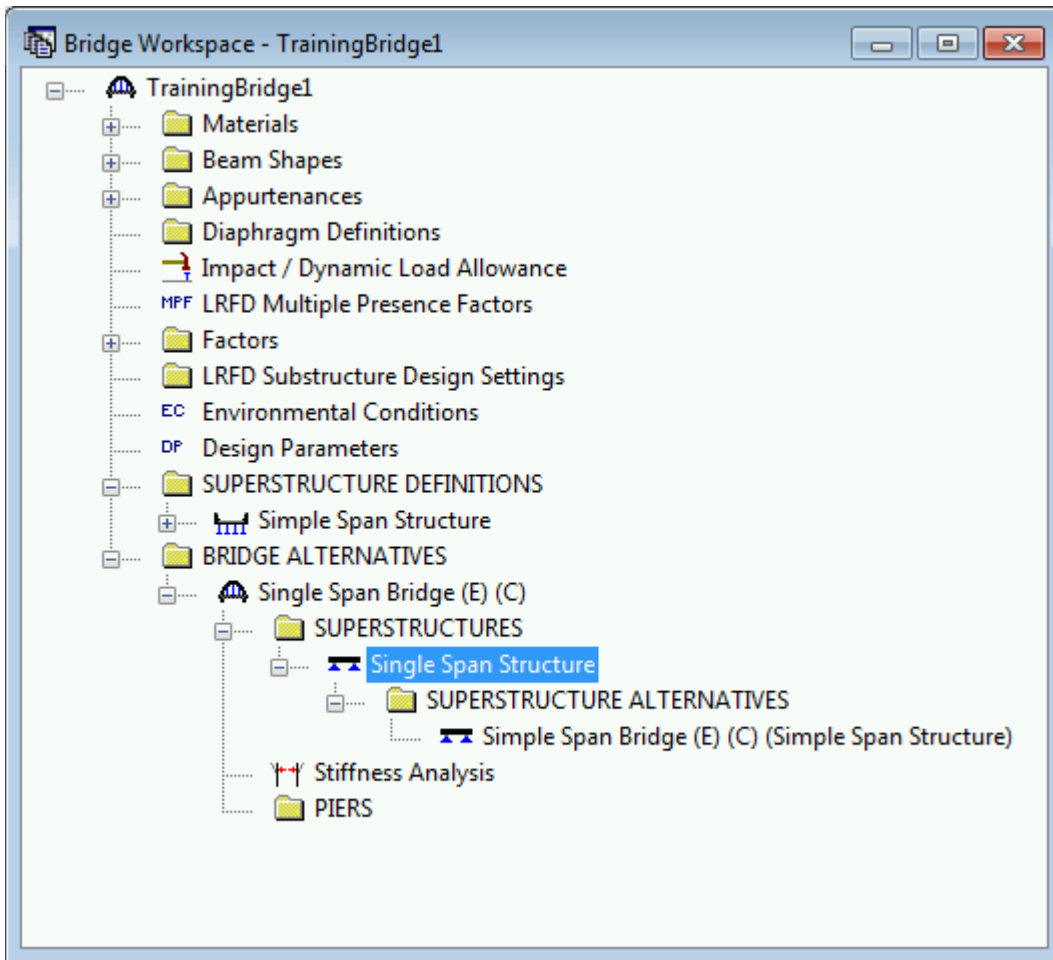




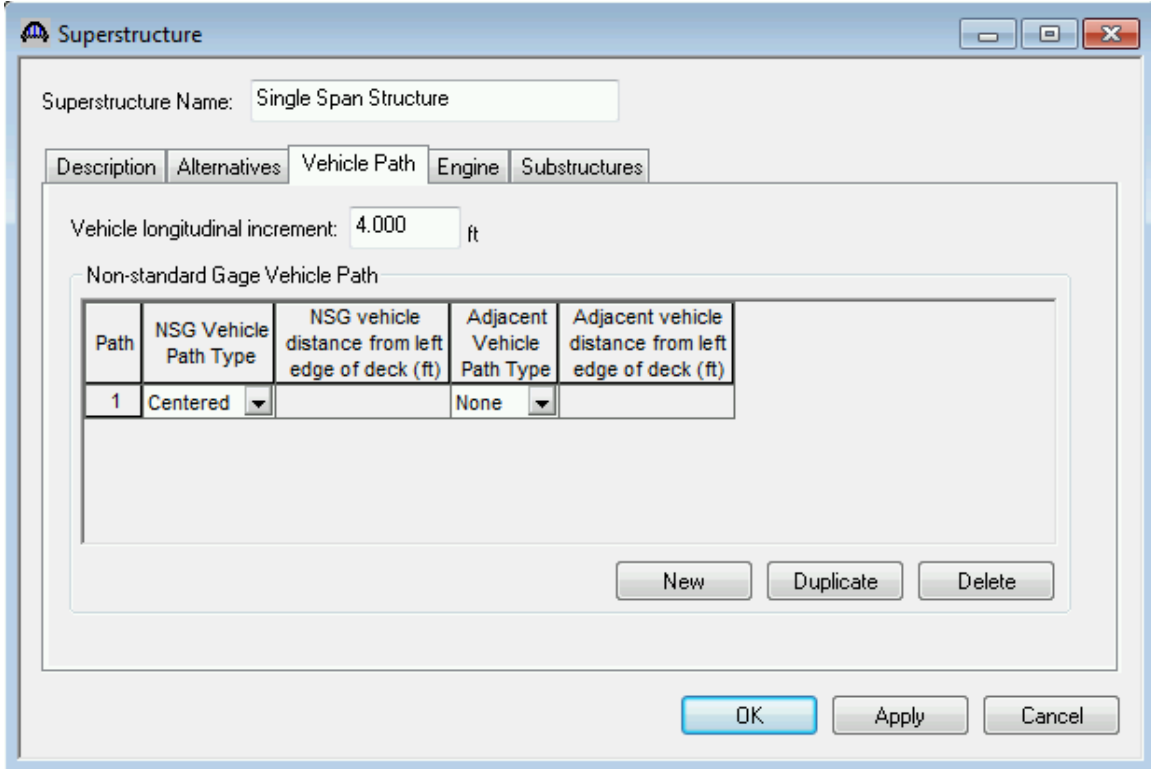
Vehicle paths

The distribution factor analysis is performed at the Superstructure level. When you perform a distribution factor analysis on a Superstructure, the analysis will be performed on the superstructure definition that is assigned to the existing Superstructure Alternative. This is necessary since in BrDR a Bridge may consist of many superstructure definitions assigned to different locations along the length of the bridge.

We are going to analyze BID1 (TrainingBridge1) in the BrDR sample database. Open the Bridge Workspace for BID1. The Bridge Workspace for BID1 is shown below. The distribution factor analysis for Single Span Structure will perform a 3D and 2D analyses of the Simple Span Structure which is assigned to the existing superstructure alternative.

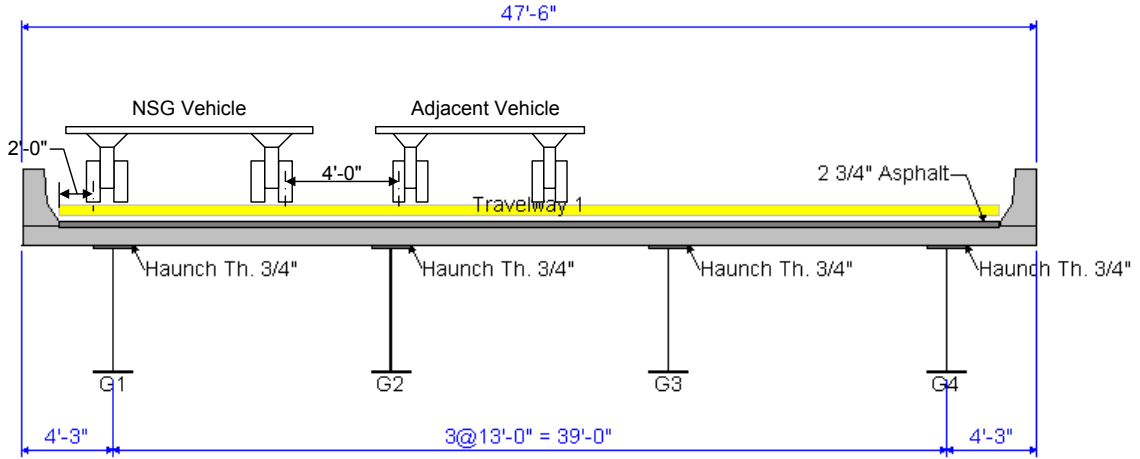


Open the Single Span Structure superstructure window and select the Vehicle Path tab.

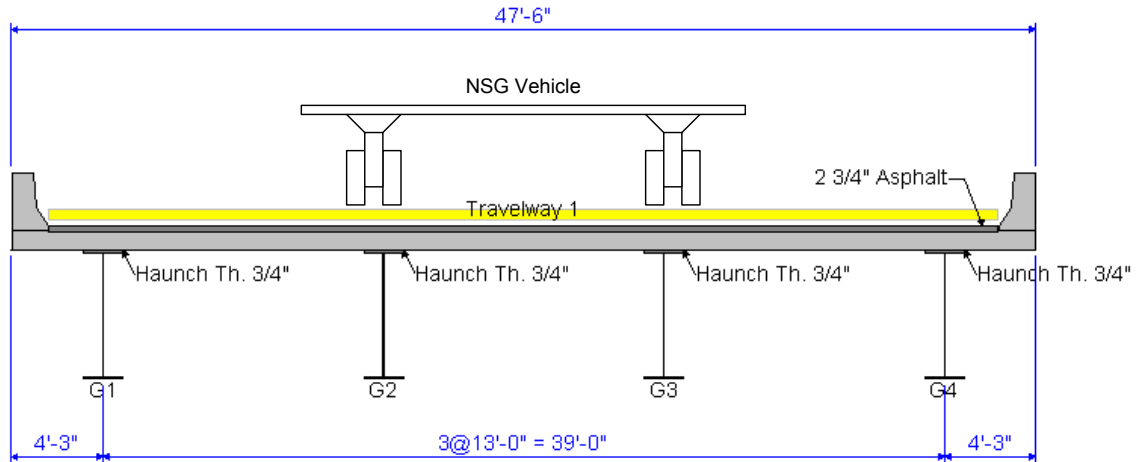


This tab controls the placement of the vehicle that will be used in the distribution factor analysis. The vehicle longitudinal increment is the longitudinal length increment to use when moving the vehicle along the length of the superstructure. Note that this value can greatly affect the time required for the analysis.

The vehicle path specifies the transverse location of the non-standard gage vehicle and an adjacent vehicle to use in the analysis. The following illustrates where the vehicles would be placed if the NSG vehicle path is specified as Left and the Adjacent vehicle path is specified as Right.

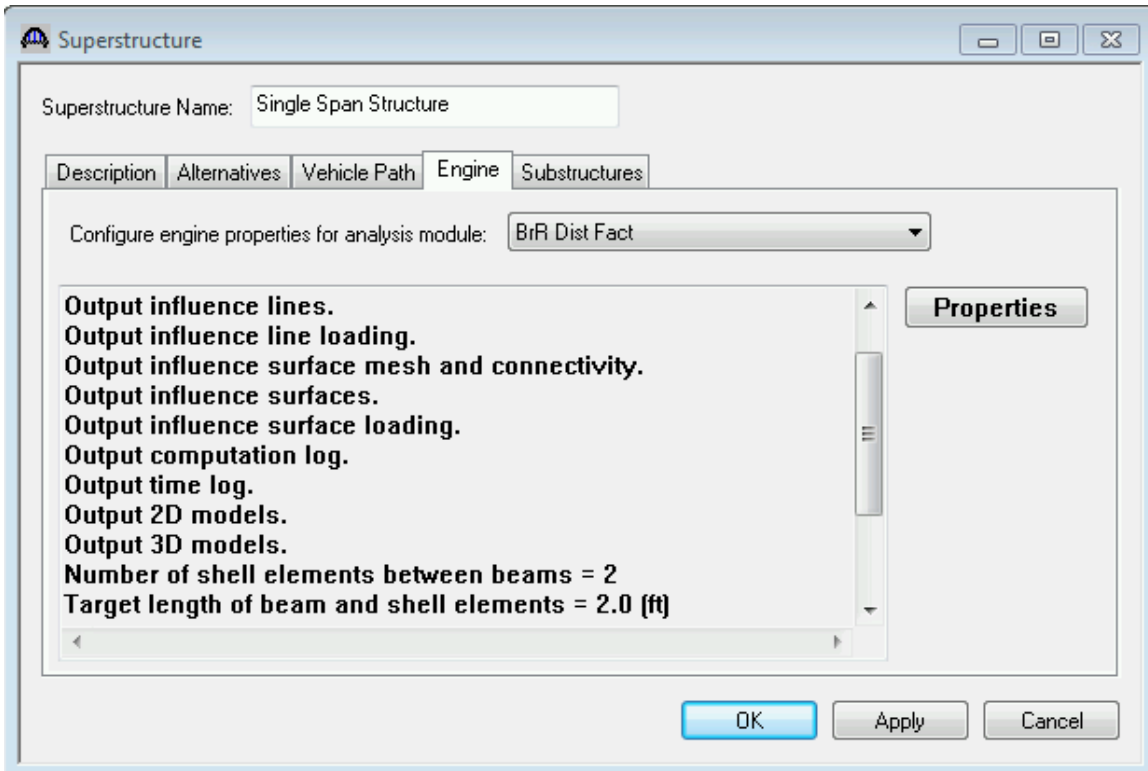


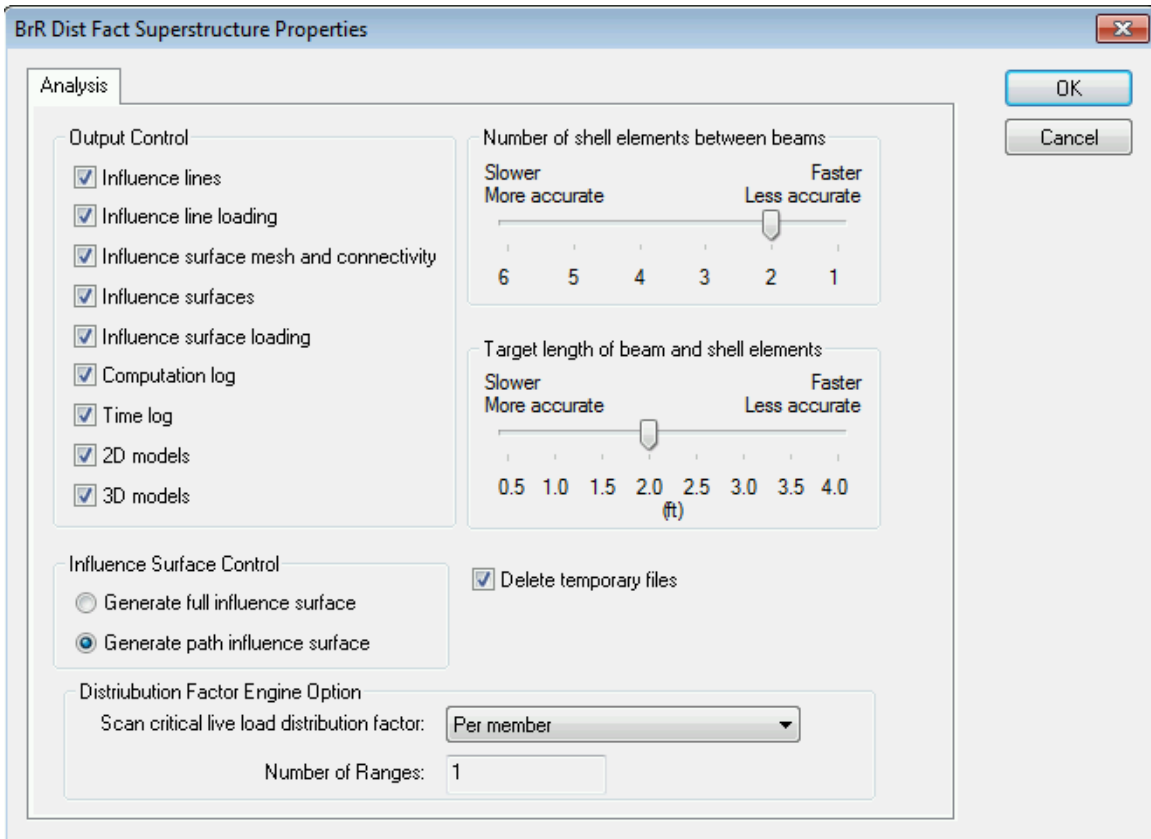
Our example uses the NSG vehicle path specified as Centered and the adjacent vehicle path as None. This path is shown below.



Part 2: BrR Distribution Factor Engine Properties

Select the Engine tab in the Single Span Structure superstructure window. The Engine tab allows you to specify properties for the analysis engine. Select BrR Dist Fact as the analysis module and then select the Properties button.





This window allows you to specify the level of output that you want from the analysis and allows you to control how the FE models are created and loaded. The Number of shell elements between beams and Target length of beam and shell element selections control the size of the elements in the model and also greatly influence the time required for the analysis.

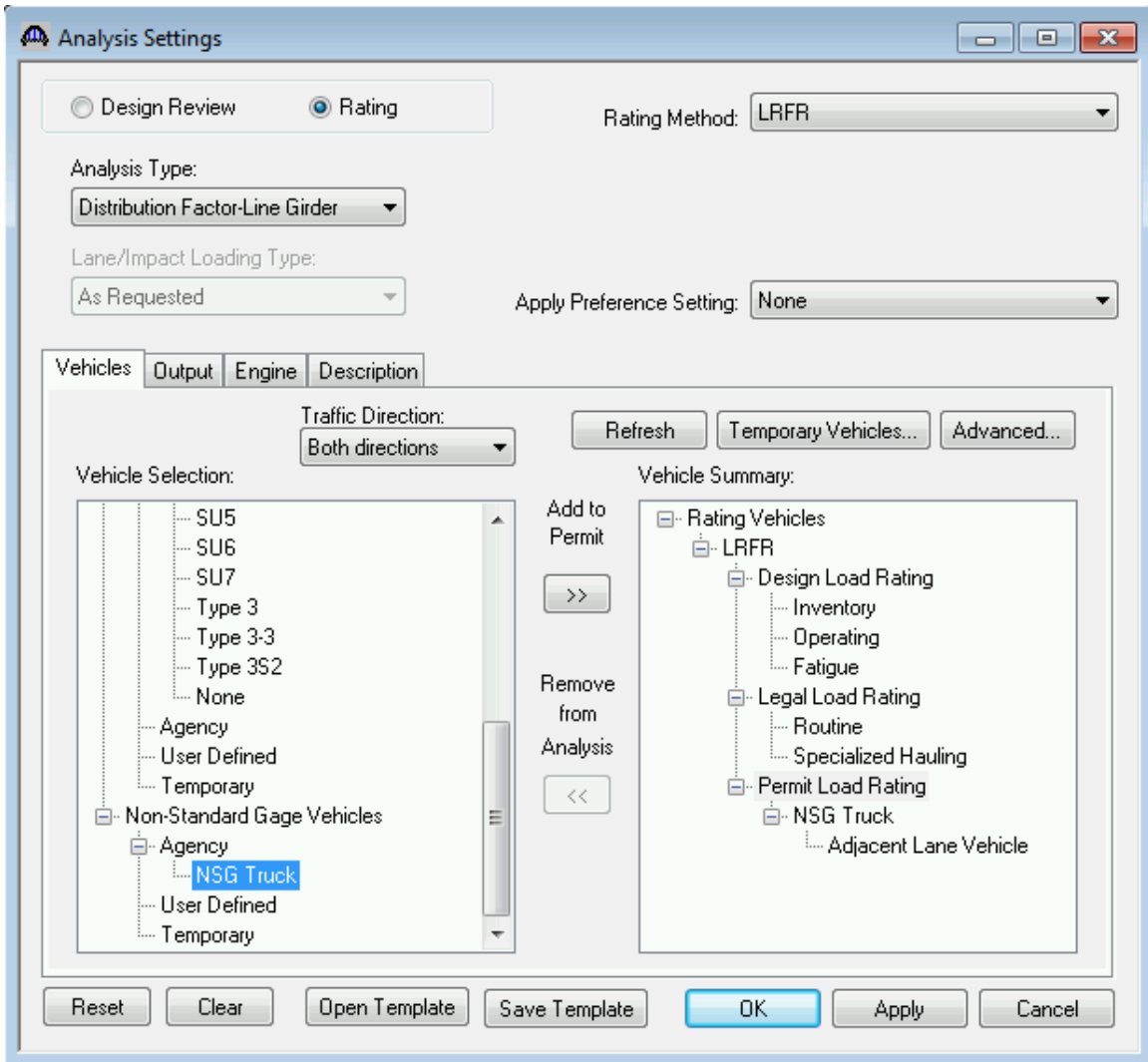
The Scan critical live load distribution factor selection allows you to specify the method for determining the critical distribution factors. The Per member option specifies one critical moment and one critical shear distribution factors to be used for the whole member. The One range per span option specifies each span in the member has its own critical moment and shear distribution factors. The Multiple ranges per span option specifies each range in a span has its own critical moment and shear distribution factors. The length of the range is the span length divided by the entered Number of Ranges.

Click OK to close the BrR Dist Fact Superstructure Properties window and then click OK again to close the Superstructure window.

Part 3: Perform LRFR Analysis.

The distribution factor analysis can be initiated by selecting the superstructure in the Bridge Workspace tree and clicking the View Analysis Settings toolbar button.

Select Distribution Factor-Line Girder as the Analysis Type and LRFR as the Rating Method. This will cause the distribution factor analysis to be performed and LRFR analysis will be performed during the traditional line girder analysis. Then select the NSG Truck as the permit vehicle to use. Note that you could select a standard gage vehicle to use in the analysis. You can also select a vehicle to use in the adjacent lane. We are not going to select a vehicle for the adjacent lane in this example.



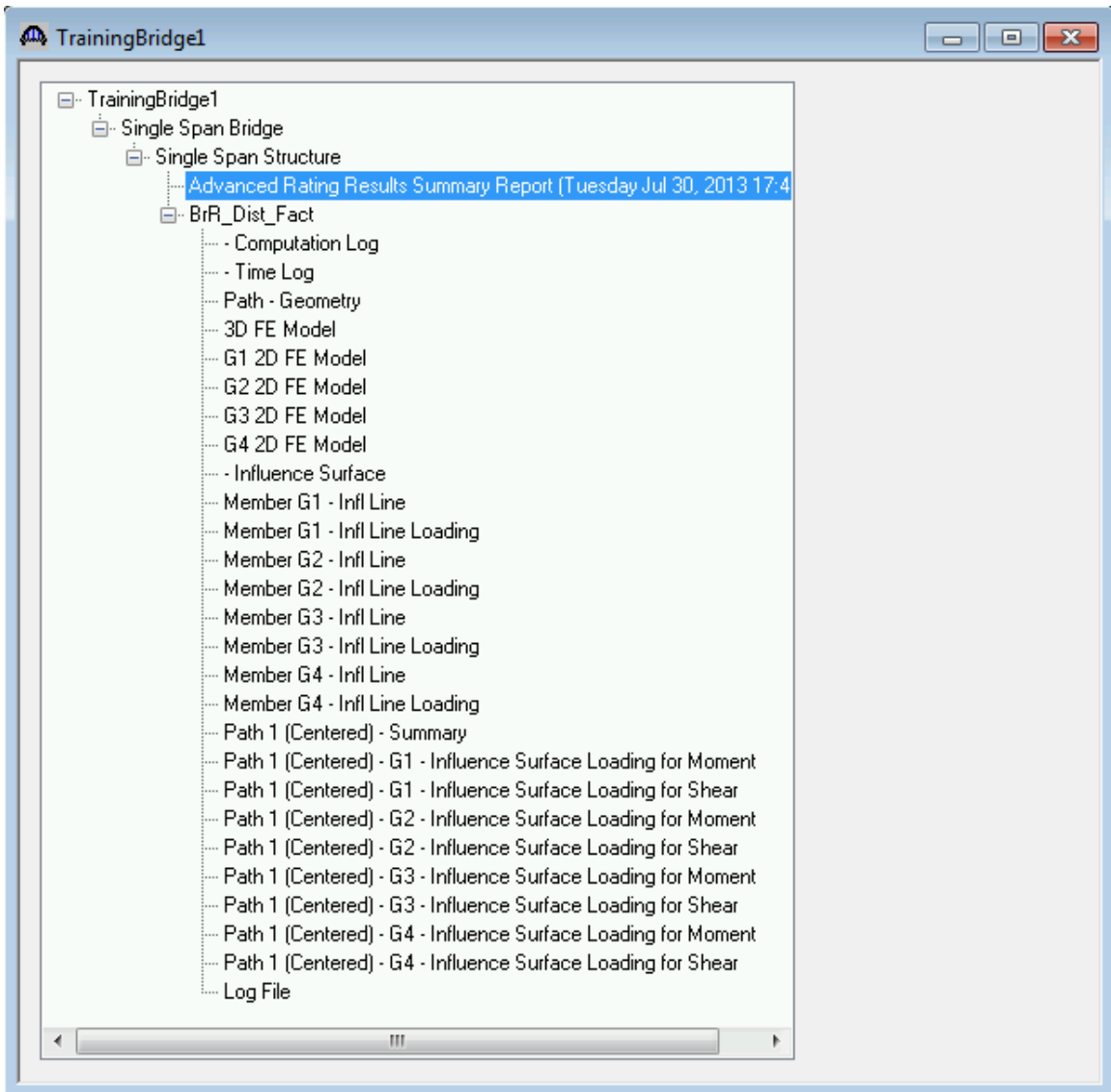
Click OK to save the settings and close the window.

Click the Analyze toolbar button to initiate the Distribution Factor-Line Girder analysis.

The Analysis Progress dialog will appear showing the progress of the 3D and 2D finite element analyses. The AASHTO LRFR Engine is then run for the traditional line girder analysis using the distribution factors computed by the distribution factor analysis.

Click OK to close the Analysis Progress dialog.

The output of the distribution factor analysis can be found by selecting the View analysis output toolbar button when the superstructure is selected in the Bridge Workspace tree.



The output of the distribution factor analysis includes the 3D and 2D finite element models, the influence surface and influence lines and their loading.

Double-click the Advanced Rating Results Summary Report for a summarized report of the rating. The critical distribution factors used for each girder are also listed in the report.

Bridge Name: Training Bridge 1(LRFD)
Bridge ID: 1
Super Structure: Single Span Structure

Analysis Date: Tuesday, July 30, 2013 17:41:32

Permit Vehicle: NSG Truck
Adjacent Permit Vehicle:

Loading Path: NSG (Centered) - ADJ (None)

Member	Permit Capacity (Ton)	Permit Location / Element Name (ft)	Permit Rating Factor	Permit Limit State	Success / Failure
G1	248.76	80.500 (1 - 50.0%)	5.654	STRENGTH-II Steel Flexure Stress	Success
G2	96.63	80.500 (1 - 50.0%)	2.196	STRENGTH-II Steel Flexure Stress	Success
G3	96.71	80.500 (1 - 50.0%)	2.198	STRENGTH-II Steel Flexure Stress	Success
G4	248.65	80.500 (1 - 50.0%)	5.651	STRENGTH-II Steel Flexure Stress	Success

Member	Start Range (ft)	End Range (ft)	Moment Dist. Factor (Lanes)	Shear Dist. Factor (Lanes)
G1	0.000	161.000	0.169	0.156
G2	0.000	161.000	0.319	0.517
G3	0.000	161.000	0.319	0.520
G4	0.000	161.000	0.170	0.156

You can view the results of the AASHTO LRFr Engine line girder analysis of each girder by selecting the member alternative in the Bridge Workspace tree and clicking the View analysis report toolbar button.